

---

**FIRST MAJOR IMPROVEMENTS TO THE TWO-CURVE DUCTILE FRACTURE ARREST MODEL – EFFECT OF DIFFERENT SOIL TYPES ON DUCTILE FRACTURE ARREST, AND SEPARATING ELASTIC AND PLASTIC CONTRIBUTIONS TO THE CRACK-DRIVING FORCE**

---

## **Summary**

The objective of the proposed program is to make the first major improvements to the most commonly used ductile fracture arrest criterion. There are two tasks in this effort.

The first task is to improve the accuracy of the Two-Curve Ductile Fracture Model to be able to account for different types of soil backfills, i.e., sand, clay, etc. To make this improvement, a series of intermediate-diameter (6 to 12-inch) pipe burst tests with different soil types, compaction, and moisture content will be conducted at the Emc<sup>2</sup> burst test site in the Mojave Desert in California.

The second task involves making an improvement to the crack-driving force equations in the Two-Curve Method so that there will be elastic and plastic contribution to the crack-driving force. Experimental results have shown that the arrest toughness value determined from the Two-Curve Ductile Fracture Model should be continually increased as the grade of the pipe is increased. A significant portion of this empirical correction comes for the elastic energy being higher than was accounted for in the current Two-Curve Ductile Fracture Model. Making this improvement will allow for safer future pipeline design with higher-grade steels.

## **Progress as of March 2006**

In the first year of this project, five small diameter pipe burst tests were conducted at the Mojave test site using different combinations of moisture and compaction levels on two different soil types. Unexpected end-plug failures caused minimal data to be taken in three of the five tests. Modifications to the test plan for future tests will allow two sets of data to be developed from each pipe test, which will make each test more economical while still meeting the program objectives. In addition, a literature review was conducted and data was gathered from old pipe tests that were used to develop the original backfill coefficients. This data was digitized and re-analyzed to verify the backfill coefficients with great success. The data was then analyzed again removing the elastic portion of the crack-driving force from the original equations. New backfill coefficients were developed.

To date in the second year of this program, an information exchange agreement between JGA and DOT/PRCI has been finalized, which will allow the free exchange of experimental, numerical, and analytical data between this program, and the large full-scale pipe experimental program conducted by the JGA. The second year experiments were conducted in August/September 2005. The results of these experiments indicate that the fracture speeds are related to the soil moisture content and shear strength. Advanced instrumentation for the measurement of dynamic crack-tip opening angle is being refined for the application of these devices to the June 2006 JGA full-scale pipe experiment.